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AGE AT HIP FRACTURE AND LIFE EXPECTANCY IN DENMARK – SECULAR TRENDS OVER TWO DECADES.

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HIGHLIGHTS

- Decreasing hip fracture rates could result in an increasing mean age of the hip fracture population.
- From 1996 to 2017 there was no difference in the age at pertrochanteric fracture in men or in women.
- We observed no change in the age at femoral neck fracture in men and only a slow increase in women.
- The female:male gender ratio for both fracture types changed strongly over this 20-year period.
- Mean life expectancy in both genders now exceeds the mean age at hip fracture.

Abstract

Background Recent improvements in the health of the oldest old coexist with a decline in hip fracture rates, in particular in women. We speculated that increased longevity with decreasing hip fracture rates would result in a delay in hip fracture. We conducted an analysis of time trends in the age at hip fracture, by type and gender, for the past two decades using national data.

Study population and methods We used data from the Danish Hospital Discharge Register **(1996-2017)** to analyse the age distribution of femoral neck (FN) and **pertrochanteric fractures (PT),** allowing only the first fracture at each of these two sites to contribute to the analysis in each calendar year. Demographics for the background population at risk including life expectancy tabulations, were also obtained.

Results The average age at FN fracture in women increased slowly but significantly by 0.035 years - or 12.8 days - per calendar year [0.035, 95% CI (0.016; 0.054), p<0.001], resulting in an increase from 79.6 to 80.4 years. There were no significant changes in the age at FN fracture in men or the age at PT fracture in women and men. Further, increases in life expectancy were considerably faster than any change observed in the age at hip fracture. In 1996, the average age at FN or PT fracture exceeded the average life expectancy in both men and women whereas the opposite was the case from 2009 and onwards in men and 2015 and onwards in women.

Conclusion **This study demonstrates a significant change in the demographics of hip fractures in Denmark over the past two decades. We observed a significant increase in the age at FN fracture in women but not in men, with no significant increase in the age at IT fracture and PT fracture. This developed much more slowly, however, than the increase in life expectancy in both sexes observed over the same period of time. Taken together, these changes resulted in a large decrease in the female to male incidence rate ratio from 2.6 and 2.5 (FN and PT, respectively) to 1.9 and 1.7.Additional effort is** required to prevent hip fractures to ensure that the increasing life expectancy is matched by a similar increase in hip-fracture free life expectancy.

Key words: Hip fracture – Osteoporosis – Epidemiology – Life Expectancy - Prevention

Introduction

Recent years have seen an improvement in the overall health of the oldest old in the industrialized world[1] and a significant decline in hip fracture rates, in particular in women[2,3]. We speculated that better health and increased longevity with decreasing hip fracture rates would result in a delay in hip fractures and hence an increasing mean age of the hip fracture population. We also considered the possibility that such a delay, if present, could differ between femoral neck (FN) fractures, which are traditionally viewed as somewhat more strongly linked to hip geometry and FN ultrastructure, and pertrochanteric (PT) fractures which may be indicative of more universal skeletal fragility[4,5]. In addition, we considered the possibility that men could represent a particular challenge as life expectancy is increasing more rapidly among Danish men than in Danish women. Further, despite the higher rates in women, Swedish researchers have noted that men experienced their hip fractures slightly earlier in life than women[6]. We therefore conducted an analysis of time trends in the age at

hip fracture, by type and gender, for the past two decades using national Danish register data and contrasted this with official life expectancy statistics from Statistics Denmark for the same period.

Methods and Study Population

National information in the Danish Hospital Discharge Register was obtained for a calculation of the age distribution of femoral neck fractures (ICD-10 code S720) and **pertrochanteric/intertrochanteric fractures (S721),** allowing only the first fracture at each of these two sites to contribute to the analysis in each calendar year and including only subjects aged 40 or above. This register has high reliability for fracture events[7–9] The analysis was restricted to primary diagnoses only. Patients with incident hip fracture events in more than one calendar year contributed to the analysis in both years as this was not an analysis of first hip fracture but of temporal trends in the demographics of the hip fracture population, including both first and recurrent hip fractures. Event rates were calculated as Incidence Rates (IR) and ratios as Incidence Rate Ratios (IRR) unless otherwise described. The annual changes in age and other variables were estimated using least-squares linear regression and the suitability of each linear model subsequently assessed through histograms and normal probability plots of the model residuals. The full regression equations and confidence intervals for the coefficients were illustrated in the graphs with a shorter summary in the results text.

Access to de-identified person level hip fracture data was approved by Statistics Denmark (ref 703382). Ethics committee approval for register studies is not required under Danish law. Demographics for the background population at risk (public domain), including life

expectancy tabulations, were obtained from Statistics Denmark (statistikbanken.dk, accessed 15th of May 2019).

Results

The average number of persons experiencing fractures of the FN or IT femur in Denmark per year was 5,744 and 3,562, respectively. The mean age at fracture was higher for **PT fractures** compared with FN fractures in women but not in men. No significant changes occurred in the ratio between FN and **PT fractures** over the twenty-year period studied (linear trend r=0.31, p=0.16).

Temporal trends in mean age for Danish hip fracture patients

Women: The average age at FN fracture (fig 1A) in women increased slowly but statistically significantly by 0.035 year - or 12.8 days - per calendar year [0.035, 95% CI (0.016; 0.053), p<0.001], resulting in an increase from 79.6 to 80.4 years. For PT fractures, the increase in mean age was short of statistical significance, 0.02 years, p=0.12. The mean age at FN fracture was 81.2 in 1996 and 82.1 in 2017. The change in age distribution of Danish women (absolute numbers) presenting with hip fractures from 1996 to 2017 is illustrated in the left panel of fig 2.

Men: Fractures occurred at a younger age on average in men than in women, especially for PT fractures. Men exhibited no significant increasing age trend, neither for PT fractures (fig 1B, p=0.12) nor FN fractures (p=0.66) . The age distribution for **male hip fracture patients**

changed little from 1996 to 2017 (fig 2, right panel).

***Gender comparison*: There was a significantly different temporal trend (i.e slope) for age at femoral neck fracture between men and women for FN fractures whereas there was no difference between men and women regarding the temporal change for PT fractures-**

Temporal trends in female: male ratio for Danish hip fracture patients

For both FN and PT fractures (fig 3), the IRR decreased strongly and significantly between 1996 and 2017, indicating a continuing reduction of the female:male gender ratio from 2.6 to 1.9 for FN fractures (linear trend r= -0.95, p<0.001) and 2.5 to 1.7 for PT fractures (linear trend r= -0.94, p<0.001). There was no statistically significant difference between the temporal trends (slope) of these two fracture types.

Fracture rates by age and gender

Absolute fracture risk as a function of gender and age (for the year 2017, fig 4) continues to follow the classical pattern for hip fractures in Europe with an exponential rise in rates after age 70-75 and with rates being higher in women.

Temporal trends in life expectancy

Over the two decades, life expectancy increased in women and particularly in men with an average annualized increment of 85 days [0.234, 95% CI (0.221 ; 0.246), p<0.001] in women and 104 days [0.286 (0.274 ; 0.298), p<0.001] in men. As illustrated in Fig 5, the increase in life expectancy was considerably faster than the change in age at hip fracture, resulting in the mean life expectancy in both genders – but most pronounced in men - now exceeding the mean age at hip fracture.

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Discussion

This study demonstrates a significant change in the demographics of hip fractures in Denmark over the past two decades. We observed a significant increase in the age at FN fracture in women but not in men, with no significant increase in the age at PT fracture. This developed much more slowly, however, than the increase in life expectancy in both sexes observed over the same period of time. Taken together, these changes resulted in a large decrease in the female to male incidence rate ratio from 2.6 and 2.5 (FN and IT, respectively) to 1.9 and 1.7. As a consequence of the delay in hip fractures being of insufficient magnitude to keep up with the change in life expectancy in both men and women, the mean age at hip fracture is now lower than the average life expectancy in both men and whereas whereas in the 1990s, the mean age at **hip fracture was higher than the average life expectancy in both genders. Though longitudinal changes in hip fracture rates are well described for a large number of countries, there is a paucity of data on age at hip fracture. In 2010, a study of hip fracture admissions to a Dublin based university hospital reported an increasing average age of hip fracture patients, from 79.5 in 1985 to 82.5 in 2006[10]. More recently[11], a much larger study using national data for the population aged 65 and over in Sweden found a similar increase with the age at hip fracture increasing by three years in women and two years in men over the 22-year period from 1987 to 2009.**

Our findings follow on from the general observation that patients with PT fractures are older than patients with FN fractures[4,12–15], though in recent years we can only confirm this to be the case in women, not men. In Sweden, the FN to IT ratio is known to have decreased very strongly between 1970 and 1996, though again much more markedly in women than in men[6]. The ratio did not change over the period of time covered in the present study and population. The decreasing female:male ratio for overall hip fractures in our analysis also extends a general trend of an increasing proportion of hip fractures occurring in men. For example, in

1993, Gullberg and Johnell[14] reported that the ratio in Malmö, Sweden, had declined from 4.2 in 1950 to 2.4 in 1991. The present IRR in Denmark is below 2:1 as discussed above. While this decrease could be related to a narrowing of the difference in life expectancy between men and women in the same period, this change in hip fracture demographics may also be influenced by a larger osteoporosis treatment gap in men compared with women [16,17]. In this context, it is important to appreciate that even a perfectly implemented fracture liaison service in men will have a fairly limited influence on first hip fracture event rates in men, because hip fractures in men are far more likely to present as the first major osteoporotic fracture rather than be preceded by fractures that would present as an opportunity for secondary prevention. Hence, in Denmark, only less than one in five male hip fracture patients has a history of major osteoporotic fracture in the ten years that preceded their hip fracture[18]. The observation that male hip fracture patients were younger on average than female hip fracture patients – echoing Swedish findings[6] - may seem to contradict the shape of the age vs rate curves shown in figure 4. However, the age distribution of the fracture population is driven not only by the fracture risk at each age point but also of the age distribution of the population at risk.

There are several potential mechanisms that can contribute to the apparent paradox of increasing life expectancy with a stagnating or only slowly increasing age at hip fracture. First, declining hip fracture rates can occur without a change in the age of hip fracture if and when the reduction in rates is uniform across all age groups. Second, the demographic changes are not only an increased life expectancy but also changes in the size of birth cohorts. Hence, the number of women aged 70 increased by 56% from 1996 (1926 birth cohort) to 2017 (1947 birth cohort), which also affects the population-at-risk. Finally, both Danish and Swedish data analyzed to a common protocol[19] for 1987 to 2010 found a relatively low risk of hip fractures in the 1930s birth cohorts with a

higher age-adjusted incidence rate in the subsequent generations, especially in women. While this emphasizes the complex interplay of generational changes in skeletal morbidity, longevity and population dynamics, the pathophysiological reasons for the changes in susceptibility of hip fracture remain incompletely understood. The modest changes to age at hip fracture observed in this study have occurred despite a large general reduction in hip fracture rates in the country. Specifically, hip fracture rates declined by 20% from 1997 to 2006[20], with an additional 30% decline from 2005 to 2015[21]

The study was based on primary diagnoses only and is therefore somewhat conservative in the inclusion criteria, given that a hip fracture may appear as a secondary diagnosis if patients are admitted due to an even more serious or more highly billable event, e.g. a patient whose hip fracture coincides with a stroke or severe head trauma. This is unlikely to induce a bias regarding time trends or gender differences as the same metric was used throughout the period. Also, as ICD-10 was introduced early in Denmark – the country went directly from ICD-8 to ICD-10 in 1994 – the whole time period covered used the same coding system with no administrative data breaks.

Additional research is needed to better understand the different pathophysiology of the two main types of hip fractures, which are often regarded as the same entity in osteoporosis epidemiology, but where risk factors, interventions as well as gender and time trends appear to be somewhat discrepant. To this end, Crilly et al noted, in a Canadian population, that the contribution of **PT fractures to the total number of hip fractures increased with increasing age in women, whereas in men about 40% of hip fractures were pertrochanteric,** irrespective of age[22]. This is not easily explained by the particular propensity for loss of FN cortical bone and strength critical location in women with age,

something that is much less pronounced in men[23].

In conclusion, a more rigorous effort is required to prevent hip fractures to ensure that the increasing life expectancy is matched by a similar increase in hip-fracture free life expectancy.

Disclosures

Bo Abrahamsen: Institutional research contracts with Novartis and UCB. Speakers fees Amgen and UCB. Henrik V.B. Laursen: None. Michael K Skjødt: Travel grant and institutional research contract with UCB. Morten H Jensen: None. Peter Vestergaard: Institutional research contracts with Novo Nordic, Eli Lilly, MSD, Kyowa Kirin, and Shire. Speakers fees Amgen, Eli Lilly, Novartis, Servier.

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References

1. Crimmins EM. Lifespan and Healthspan: Past, Present, and Promise. *Gerontologist*. 2015;55(6):901-911. doi:10.1093/geront/gnv130

2. Lucas R, Martins A, Severo M, et al. Quantitative modelling of hip fracture trends in 14 European countries: Testing variations of a shared reversal over time. *Sci Rep*. 2017;7(1):1-10. doi:10.1038/s41598-017-03847-x

3. Abrahamsen B, Skjødt MK, Vestergaard P. Hip fracture rates and time trends in use of anti-osteoporosis medications in Denmark for the period 2005 to 2015: Missed opportunities in fracture prevention. *Bone*. 2019;120(October 2018):476-481. doi:10.1016/j.bone.2018.12.016

4. Mautalen CA, Vega EM, Einhorn TA. Are the etiologies of cervical and trochanteric hip fractures different? *Bone*. 1996;18(3 Suppl):133S-137S. http://www.ncbi.nlm.nih.gov/pubmed/8777078. Accessed May 19, 2019.

5. Watt J, Cox L, Crilly RG. Distribution of vertebral fractures varies among patients according to hip fracture type. *Osteoporos Int*. 2015;26(3):885-890. doi:10.1007/s00198-014-2887-y

6. Löfman O, Berglund K, Larsson L, Toss G. Changes in hip fracture epidemiology: Redistribution between ages, genders and fracture types. *Osteoporos Int*. 2002;13(1):18-25. doi:10.1007/s198-002-8333-x

7. Hundrup YA, Hoidrup S, Obel EB, Rasmussen NK. The validity of self-reported fractures among Danish female nurses: comparison with fractures registered in the Danish National Hospital Register. *Scand J Public Heal*. 2004;32:136-143.

8. Frank L. Epidemiology. When an entire country is a cohort. *Science (80-).* 2000;287(5462):2398-2399.

9. Andersen TF, Madsen M, Jorgensen J, Mellemkjoer L, Olsen JH. The Danish National Hospital Register. A valuable source of data for modern health sciences. *DanMedBull*. 1999;46:263-268.

10. Green C, Molony D, Fitzpatrick C, O'Rourke K. Age-specific incidence of hip fracture in the elderly: A healthy decline. *Surgeon*. 2010;8(6):310-313. doi:10.1016/j.surge.2010.05.008

11. Nilson F, Moniruzzaman S, Gustavsson J, Andersson R. Trends in hip fracture incidence rates among the elderly in Sweden 1987-2009. *J Public Heal (United Kingdom)*. 2013;35(1):125-131. doi:10.1093/pubmed/fds053

12. Zain Elabdien BS, Olerud S, Karlström G, Smedby B. Rising incidence of hip fracture in Uppsala, 1965-1980. *Acta Orthop Scand*. 1984;55(3):284-289. http://www.ncbi.nlm.nih.gov/pubmed/6741475. Accessed May 30, 2019.

13. Greenspan SL, Myers ER, Maitland LA, Kido TH, Krasnow MB, Hayes WC. Trochanteric bone mineral density is associated with type of hip fracture in the elderly. *J Bone Miner Res*. 1994;9(12):1889-1894. doi:10.1002/jbmr.5650091208

14. Gullberg B, Duppe H, Nilsson B, et al. Incidence of hip fractures in Malmö, Sweden (1950-1991). *Bone*. 1993;14 Suppl 1:S23-9. http://www.ncbi.nlm.nih.gov/pubmed/8110516. Accessed May 30, 2019.

15. Nakamura N, Kyou T, Takaoka K, Ohzono K, Ono K. Bone mineral density in the proximal femur and hip fracture type in the elderly. *J Bone Miner Res*. 1992;7(7):755-759. doi:10.1002/jbmr.5650070705

16. Leslie WD, Giangregorio LM, Yogendran M, et al. A population-based analysis of the post-fracture care gap 1996–2008: the situation is not improving. *Osteoporos Int*. 2012;23(5):1623-1629. doi:10.1007/s00198-011-1630-1

17. Roerholt C, Eiken P, Abrahamsen B. Initiation of anti-osteoporotic therapy in patients with recent fractures: A nationwide analysis of prescription rates and persistence. *Osteoporos Int*. 2009;20(2):299-307. doi:10.1007/s00198-008-0651-x

18. Frederiksen A, Abrahamsen B, Johansen PB, Sørensen HA. Danish, national cross-sectional observational study on the prevalence of prior major osteoporotic fractures in adults presenting with hip fracture—limitations and scope for fracture liaison services in prevention of hip fracture. *Osteoporos Int*. 2018;29(1):109-114. doi:10.1007/s00198-017-4247-1

19. Rosengren BE, Björk J, Cooper C, et al. Recent hip fracture trends in Sweden and Denmark with age-period-cohort effects. *Osteoporos Int*. 2017;28(1):139-149. doi:10.1007/s00198-016-3768-3

20. Abrahamsen B, Vestergaard P. Declining incidence of hip fractures and the extent of use of anti-osteoporotic therapy in Denmark 1997-2006. *Osteoporos Int*. 2010;21(3):373-380. doi:10.1007/s00198-009-0957-3

21. Abrahamsen B, Skjødt MK, Vestergaard P. Hip fracture rates and time trends in use of anti-osteoporosis medications in Denmark for the period 2005 to 2015: Missed opportunities in fracture prevention. *Bone*. 2019;120(December 2018):476-481. doi:10.1016/j.bone.2018.12.016

22. Crilly RG, Kloseck M, Mequanint S. Hip Fracture Types in Canadian Men and Women Change Differently with Age: A Population-Level Analysis. *Clin Med Insights Arthritis Musculoskelet Disord*. 2016;9:75-79. doi:10.4137/CMAMD.S38531

23. Johannesdottir F, Aspelund T, Reeve J, et al. Similarities and differences between sexes in regional loss of cortical and trabecular bone in the mid-femoral neck: the AGES-Reykjavik longitudinal study. *J Bone Miner Res*. 2013;28(10):2165-2176. doi:10.1002/jbmr.1960

Legends

Fig 1A Changes in mean age at femoral neck fracture in Denmark from 1996 to 2017 for men (black curve) and women (dark grey curve), with linear trend lines (dotted) and R^2 for the linear regression. See text for details.

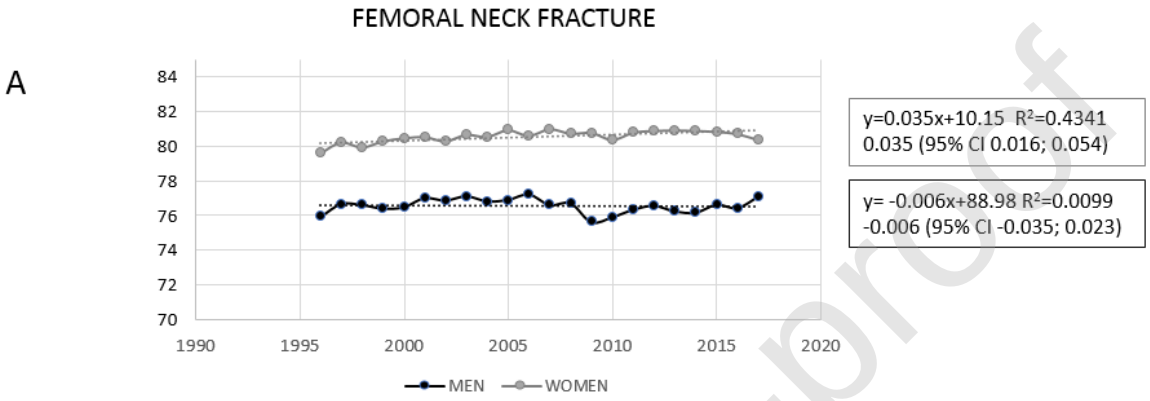

Fig 1B Changes in mean age at pertrochanteric fracture in Denmark from 1996 to 2017 for men (black curve) and women (dark grey curve), with linear trend lines (dotted) and R^2 for the linear regression. See text for details.

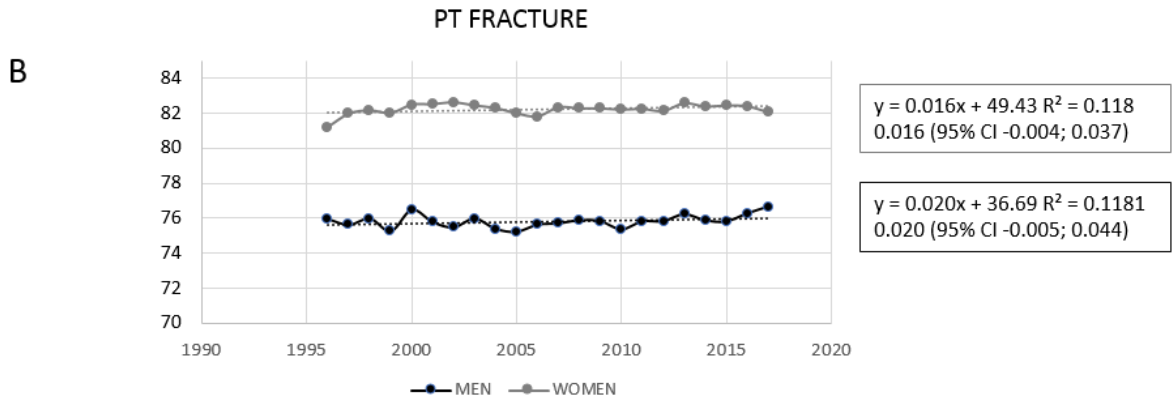

Fig 2 Incidence (absolute N) of hip fractures in 1996 (dotted grey curve) and 2017 (solid black curve) as a function of age. Shown specifically for women (left) and men (right) with separate curves for FN and PT fractures.

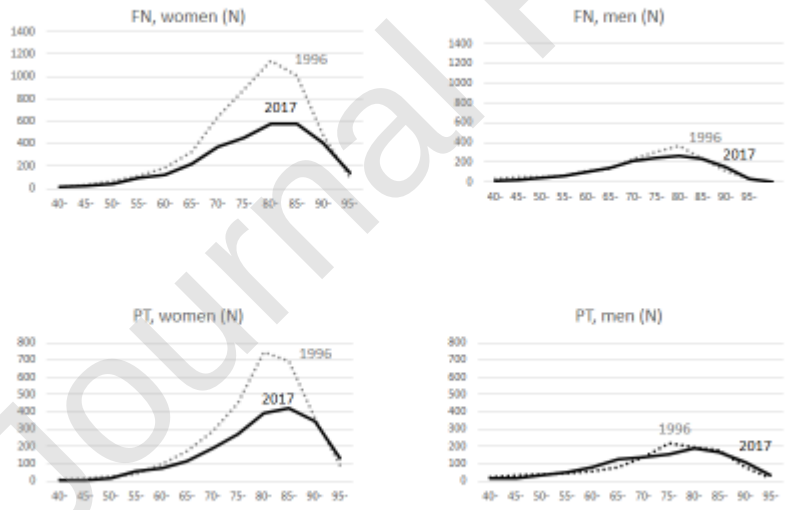

Fig 3 Female to Male incidence rate ratios for FN (black) **and PT** (grey) fractures in Denmark 1996 to 2017.

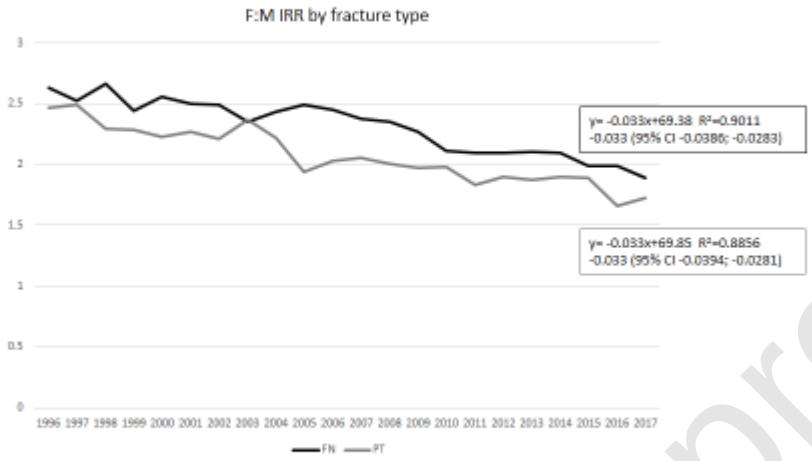

Fig 4 Incidence rates for hip fractures in Denmark for the year 2017 by age, gender (F and M) and fracture type:. Solid lines indicate FN fracture (grey for women, black for men) and dotted lines PT fractures (grey for women, black for men)

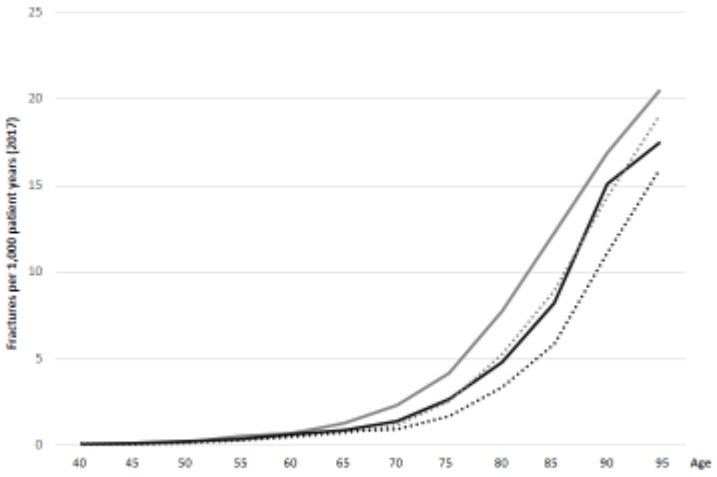

Fig 5 Development in Life Expectancy (columns) and mean age at FN (black curves) and PT fracture (grey curves) in Denmark 1996 to 2017. Men and women shown separately.